INDOOR AIR QUALITY ASSESSMENT

Goodyear Elementary School
41 Orange Street
Woburn, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response Indoor Air Quality Program

August 2005

Background/Introduction

At the request of parents and the Woburn School Department, the Massachusetts Department of Public Health's (MDPH) Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality at the Goodyear Elementary School (GES), 41 Orange Street, Woburn, Massachusetts. The assessment was prompted by parents with children who were diagnosed with type 1 diabetes. The parents were concerned with the potential link between type 1 diabetes and environmental factors that may be present at the GES.

On September 3, 2004, a visit to conduct a preliminary walkthrough of the building was conducted by Michael Feeney, Director of Emergency Response/Indoor Air Quality Program (ER/IAQ), CEH. Mr. Feeney was accompanied by Cathy Gallagher, Risk Communicator of CEH's Community Assessment Program (CAP). On September 29, 2004, CEH's CAP issued an *Evaluation of School Children Diagnosed with Type 1 Diabetes in Woburn, MA*, which is attached as Appendix A. In brief the investigation of Type I diabetes did not suggest that environmental factors at the school were likely to have played a primary role in these diagnoses.

On February 16, 2005, CEH ER/IAQ staff returned to conduct an indoor air quality assessment of the building. Cory Holmes, an Environmental Analyst in the ER/IAQ Program, assessed the GES, while accompanied by Tom Lamson, Head Custodian. The results of Mr. Feeney's preliminary assessment of IAQ and findings of Mr. Holmes' February, 2005 visit are the subject of this report.

The GES is a two-story, red brick building constructed in 1926. A single-story wing was built in 1964 and in 2000 several modular classroom units were added. Windows in both the 1926 and 1964 buildings are operable but many are in disrepair and are reportedly difficult to open.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID).

Results

The GES houses grades K through five, with a student population of approximately 240 and a staff of approximately 25. Tests were taken under normal operating conditions and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were elevated above 800 parts per million parts (ppm) of air in ten of twenty-three areas surveyed, indicating inadequate air exchange in a number of areas, mainly due to inoperable and/or poorly operating mechanical ventilation equipment. It is also important to note that areas with carbon dioxide levels below 800 ppm were sparsely populated, unoccupied and/or had windows open, which can greatly reduce carbon dioxide levels. Carbon dioxide levels would be expected to be higher with full occupancy, especially during the heating season when exterior doors and windows are closed.

Fresh air in classrooms of the 1926 and 1964 sections of the building is supplied by unit ventilator (univent) systems (Pictures 1 and 2). A univent is designed to draw air from outdoors through a fresh air intake located on the exterior wall of the building (Pictures 3 and 4). Univents in the 1926 section of the building do not have air intakes on exterior walls but are equipped with a vent scoop on the top of univents (Picture 1), which require the opening of windows to introduce fresh air into the units. Return air is drawn through an air intake located at the base of each unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit.

Univents appear to be original equipment, approximately 35 to 75 years old. Function of such aged equipment is difficult to maintain, since compatible replacement parts are often unavailable. Due to the age of the equipment, univents in the 1926 section of the building were not operating at the time of the assessment. As a result, no mechanical means for providing fresh air to these classrooms exists. Univents in the 1964 wing were operating weakly; therefore the introduction of outside air was limited. To facilitate air exchange, Mr. Lamson has stationed portable fan units on top of univent air diffusers (Picture 2). The nurse’s office and resource room 18 have neither windows nor mechanical or passive ventilation for air exchange. A fresh air source is necessary for the dilution of indoor air pollutants.

Exhaust vents powered by rooftop motors (Picture 5) are located in coat closets. The location of exhaust vents allows for them to be easily blocked by stored materials (Pictures 6 and 7). In order to function properly, these vents must remain free of obstructions. All exhaust vents were operating throughout the building during the assessment.

Ventilation for modular classrooms was originally provided by rooftop air-handling units (AHUs). All AHUs, with the exception of the one shown in Picture 8, have been removed due to chronic roof leaks; therefore, openable windows remain the only means to introduce fresh air into these rooms. The rooftop AHU in Picture 8 (Mrs. Lane's room) distributes air into the classrooms via ductwork connected to ceiling-mounted air diffusers. Return vents draw air back to the AHU through ceiling-mounted grilles. A thermostat controls the AHU and has fan settings of "on" and "automatic". The automatic setting on the thermostat activates the ventilation system at a preset temperature. Once the preset temperature is reached, the system is deactivated. Therefore, no mechanical ventilation is provided until the thermostat re-activates the system. The thermostat in Mrs. Lane's room was set to the fan "on" setting during the assessment, which provides continuous air exchange.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The majority of mechanical ventilation systems, in their current condition, cannot be balanced.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide see Appendix B.

The assessment occurred on a day of unseasonably warm weather for New England in February with an outdoor temperature reading of 50 ^{o} F. Indoor temperature readings ranged from 69^{o} F to 76 ^{o} F, which were within or very close to the lower end of the MDPH recommended comfort guidelines during the assessment. The MDPH recommends that indoor air temperatures be maintained in a range of 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Complaints of extreme temperature, mostly cold, were expressed in a number of areas, primarily in the 1964 wing. Temperature control is often difficult in a building with abandoned or nonfunctioning ventilation systems and loose/drafty single paned windows. As discussed earlier, to help achieve comfortable temperatures in the 1964 wing, supplemental heating fans are stationed on top of univent air diffusers (Picture 2).

The relative humidity ranged from 30 to 44 percent, which was below the MDPH recommended comfort range in all areas, with the exception of the cafeteria. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

During the September 3, 2004 visit, Mr. Feeney (Director of MDPH’s ER/IAQ program) observed the remediation of water damaged materials in the modular classroom wing. Water damaged materials were removed and discarded in a dumpster located at the front of the school’s parking lot (Pictures 9 and 10). The following remediation steps were taken to repair water damage to the modular classroom wing:

- Water damaged gypsum wallboard was removed and replaced.
- Rotted exterior wooden walls were removed and replaced (Picture 11).
- Water damaged carpeting was removed. New carpeting was being installed during this assessment.

In addition to these steps, Mr. Feeney also recommended that water damaged insulation (Picture 12) be discarded and that mold be cleaned from roof rafters (Picture 13).

The likely cause of the water damage was a lack of appropriate water drainage from the roof. Exterior walls of the modular classrooms showed signs of water damage, as a result of leaks from the gutter/downspout system. The water damage in the repaired section was directly under a roof spillway (Picture 14) that directed rainwater off the slightly sloped roof. This type of drainage allows water to chronically wet the exterior wall below this spillway, thereby degrading the wall surface and allowing water penetration to the interior. In order to avoid further damage to the exterior wall, water drainage from the modular roof should be configured in a manner to prevent rainwater from draining down the exterior wall.

Exterior walls had spaces/cracks in brickwork. In many areas mortar around exterior brickwork appeared to be crumbling or missing (Pictures 15 and 16). These conditions are breaches of the building envelope and can provide a means for water entry into the building. Repeated water penetration can result in the chronic wetting of building materials and the potential for microbial growth. In addition large wall cracks may provide a means of egress for pests/rodents into the building.

A number of areas had water-stained ceiling tiles, which can indicate leaks from the roof or plumbing system (Picture 17). Water-damaged porous building materials can provide a source for mold and should be replaced after a water leak is discovered and repaired.

Plants were noted in several classrooms (Picture 18). Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold.

Other IAQ Evaluations

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants; however, the pollutant produced is dependent on the material combusted. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, MDPH staff obtained measurements for carbon monoxide and PM2.5.

Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient-Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. *Carbon monoxide should not be present in a typical, indoor environment.* If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detect or ND (Table 1). Carbon monoxide levels measured in the school were also ND.

The NAAQS originally established exposure limits for particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (Us EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment. Outdoor PM2.5 concentrations were measured at 53 μg/m^3 (Table 1). PM2.5 levels measured indoors ranged from 21 to 41 μg/m^3, which were below background and the NAAQS of 65 μg/m^3. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were ND (Table 1). Indoor TVOC measurements throughout the building were also ND.

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products (e.g., the concentration of TVOCs within a classroom increases when the product is in use). While no TVOC levels measured exceeded background levels, materials containing VOCs were present in the school. At the time of the

February 16, 2005 follow-up assessment, a gas-powered snow blower was being stored in room 18, which is a small interior room with no mechanical supply ventilation or openable windows (Picture 19). Odors and off-gassing of VOCs from gasoline can have an adverse effect on indoor air quality. The alternative storage area for the snow blower is reportedly the crawlspace underneath the portable classrooms (Picture 20); odors and fumes can potentially migrate to the above classrooms.

The computer room contained a mimeograph machine (Picture 21), which can produce irritating odors during use. Mimeograph duplicating fluid contains methanol (methyl alcohol), which is a VOC that readily evaporates at room temperature. The off gassing of this material can be irritating to the eyes, nose and throat. Methanol is also a highly flammable material, which can be ignited by either flame or electrical source (Picture 22).

Several classrooms contained dry erase boards and dry erase markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), (e.g., methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat. Cleaning products were found on countertops and in unlocked cabinets beneath sinks in some classrooms. Like dry erase materials, cleaning products contain VOCs and other chemicals that can be irritating to the eyes, nose and throat of sensitive individuals.

Several other conditions that can affect indoor air quality were noted during the assessment. Exposed fiberglass insulation was noted around pipes (Picture 23). Fiberglass insulation can be a source of skin, eye and respiratory irritation.

Also of note was the amount of materials stored inside classrooms. In several areas, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Dust can be irritating to the eyes, nose and respiratory tract. For this reason, items should be relocated and/or cleaned periodically to avoid excessive dust build up.

Several areas contained window-mounted air conditioners and/or portable air purifiers. This equipment is normally fitted with filters. To avoid the build up and re-aerosolization of dirt, dust and particulate matter, filters should be cleaned or changed as per manufacturer's instructions.

Conclusions/Recommendations

The repairs to the water damaged modular classroom are consistent with MDPH recommendations for remediation. Some further actions to prevent the reoccurrence of water damage were made by the Woburn School Department (e.g., removing the rooftop AHUs to reduce weight stress contributing to water pooling). These improvements, combined with the installation of univents for modular classrooms, should improve indoor air quality.

The conditions related to general indoor air quality problems at the GES raise a number of issues. The general building conditions, maintenance, work hygiene practices and the condition of mechanical ventilation equipment, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons, a two-phase approach is required. This approach consists of **short-term** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns.

The following **short-term** measures should be considered for immediate implementation:

1. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the optimal operability of univents.
2. Operate all ventilation systems that are operable throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy independent of thermostat control to maximize air exchange.
3. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
4. Use openable windows in conjunction with classroom exhaust vents to create air exchange. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
5. Install a passive vent in the door of the nurse's office and room 18 to provide air exchange.
6. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

7. Ensure leaks are repaired and replace water damaged ceiling tiles. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.

8. Repair leaks to gutters and downspouts on the roof of modular classrooms, if not already accomplished.

9. Contact a masonry firm or general contractor to repair holes/breaches in exterior walls to prevent water penetration, drafts and pest entry.

10. Repair/replace broken windows; re-seal loose window frames to prevent drafts and water penetration.

11. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary. Keep plants away from the air stream of univents. Consider reducing the number of plants in certain areas.

12. Encapsulate exposed pipe insulation to avoid the aerosolization of fiberglass fibers.

13. Store gas-powered equipment outside the building.

14. Store cleaning products properly and out of reach of students.

15. Consider discontinuing the use of mimeograph machine.

16. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

17. Clean/change filters for window-mounted air conditioners and air purifiers as per the manufactures' instructions, or more frequently if needed.

18. For further information on mold, consult "Mold Remediation in Schools and Commercial Buildings" published by the US EPA (2001). Copies of this document can

be downloaded from the US EPA website at:

http://www.epa.gov/iaq/molds/mold_remediation.html.

19. Consider adopting the US EPA (2000b) document "Tools for Schools" to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at: http://www.epa.gov/iaq/schools/index.html.

20. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

The following **long-term measures** should be considered:

1. Based on the age, physical deterioration and availability of parts for ventilation components, the MDPH strongly recommends that an HVAC engineering firm fully evaluate the ventilation systems throughout the building.
2. Examine the feasibility of repair vs. replacement of univents. Determine if existing vents, ductwork, etc. can be retrofitted for (modern) mechanical ventilation.
3. Evaluate thermostat settings throughout the school. Thermostats should be set at temperatures to maintain comfort for building occupants.
4. Consider having exterior walls re-pointed and waterproofed to prevent water intrusion. This measure should include a full building envelope evaluation.
5. Replace/repair window systems throughout the building -wide to prevent water penetration and drafts through window frames.

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Picture 1

Classroom Univent 1920's Vintage, Note Vent "Scoop" on top of Unit Requiring the Opening of Windows to Introduce Fresh Air

Picture 2

Classroom Univent 1960's Vintage, Note Portable Fan Unit on Air Diffuser to Facilitate Air Exchange

Picture 3

Univent Air Intake for 1964 Wing

Picture 4

Univent Air Intake for 1964 Wing

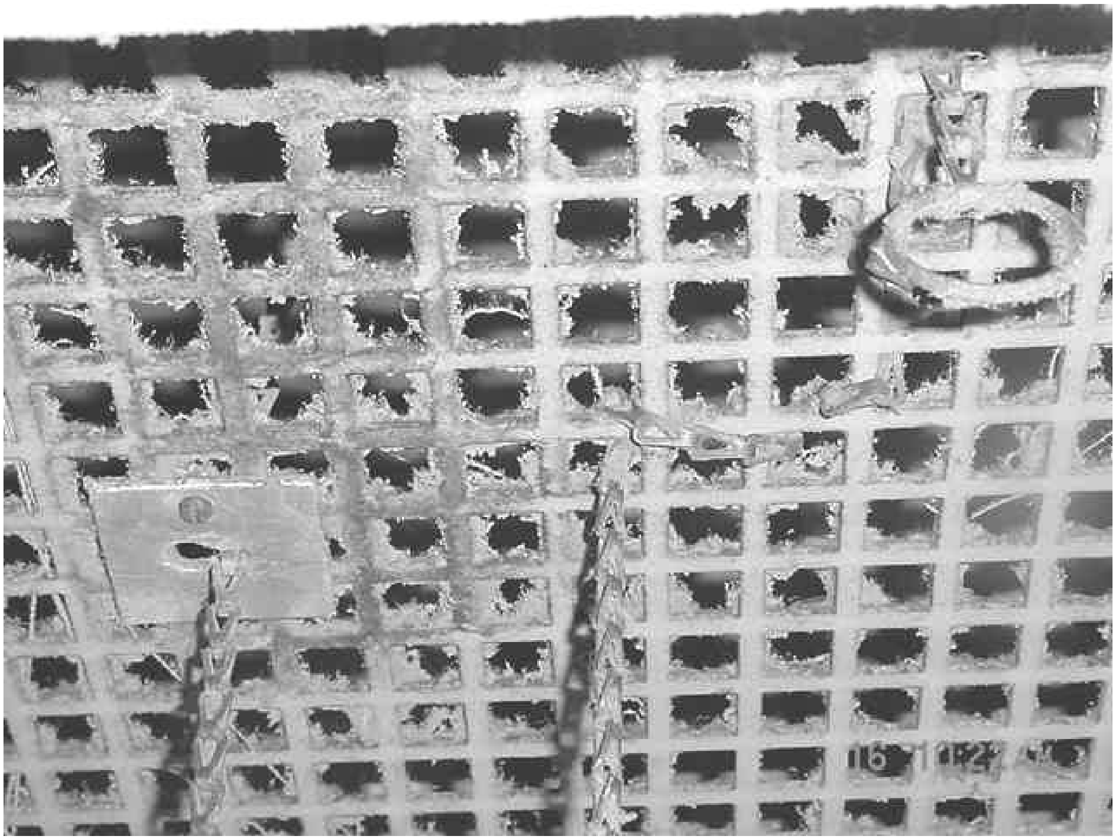
Picture 5

Rooftop Exhaust Motors

Picture 6

Coat Closet Exhaust Vent Obstructed by Box

Picture 7



Close-Up of Coat Closet Exhaust Vent, Note Pull Chain to Adjust Flue and Dust Accumulation

Picture 8

Sole Remaining AHU, Arrows Indicate AHUs That Have Been Removed

Picture 9

Dumpster In Front Of Building

Picture 10

Moldy Gypsum Wallboard and Other Demolition Materials Related To Modular Renovations

Picture 11

Fully Repaired Exterior, West Wall of Modular Classroom

Picture 12

Moldy Insulation

Picture 13

Mold Contaminated 2’ X’4’ Rafter, Modular Classroom

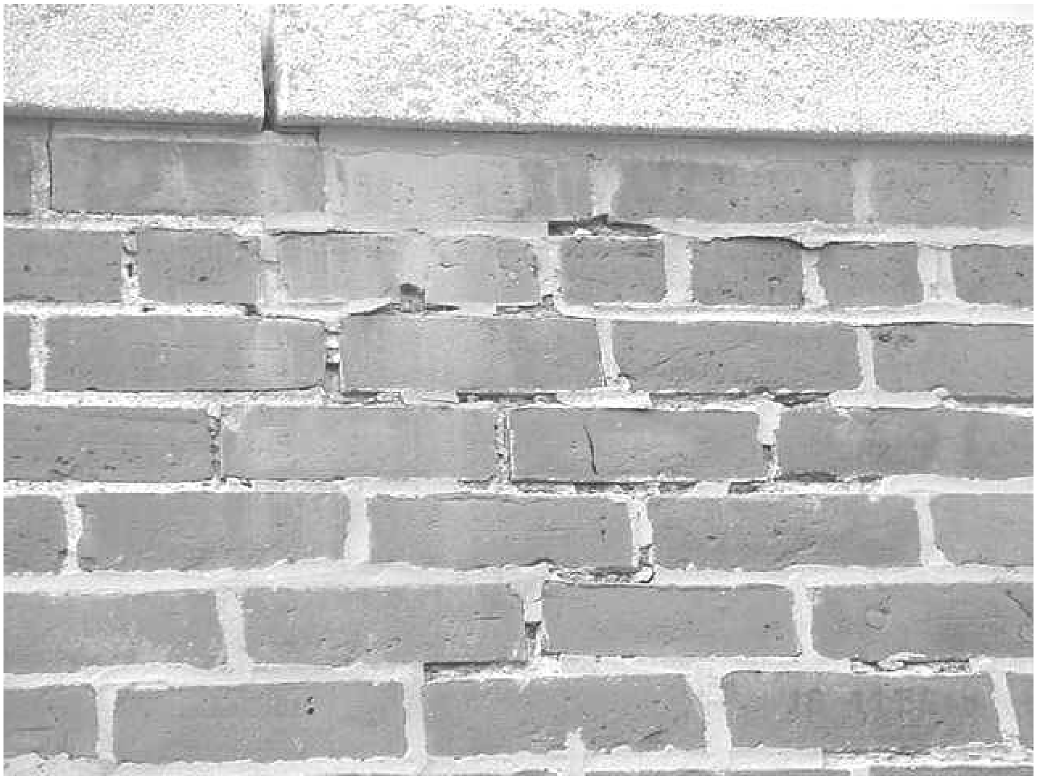
Picture 14

Spillway without Gutter/Downspout, West Wall, Modular Classrooms

Picture 15

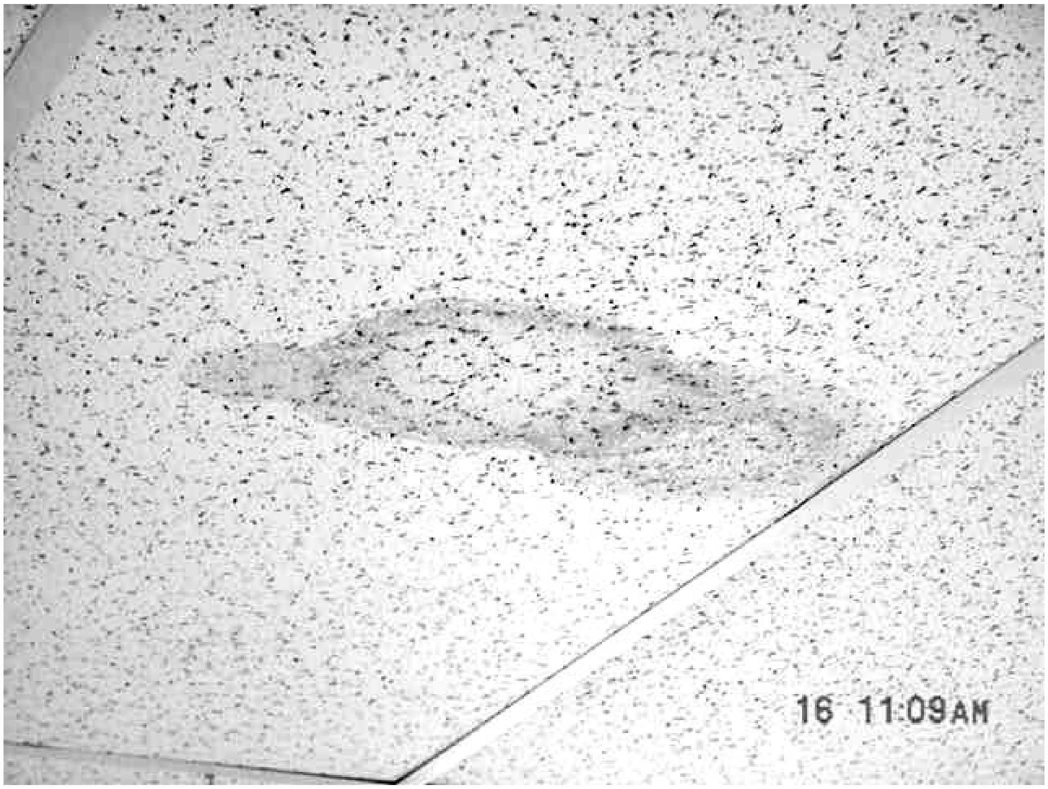
Missing/Damaged Mortar/Brickwork

Picture 16



Missing/Damaged Mortar/Brickwork

Picture 17



Water Damaged Ceiling Tile

Picture 18

Plants in Classroom

Picture 19

Snow Blower (Behind Shopping Cart) Stored in Room 18

Picture 20

Crawlspace Beneath Modular Classrooms, Note Gas Powered Mower and Edger

Picture 21

Mimeograph Machine With Flammable Duplicating Fluid

Picture 22

Close-Up of Poison/Flammable Label on Duplicating Fluid

Picture 23

Exposed Fiberglass Pipe Wrap

Goodyear Elementary School		**Indoor Air Results**

Goodyear Elementary School

41 Orange St., Woburn, MA

Table 1

Indoor Air Results

February 16, 2005

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background	0	50	55	360	ND	ND	53	N # open: 0 # total: 0			Comments: weather conditions: partly cloudy, SE winds 10-20 mph, heavy to moderate traffic.
Art Room	0	72	38	1012	ND	ND	35	Y # open: 0 # total: 5	Y univent	Y closet	Hallway DO, plants.
9	3	72	33	564	ND	ND	29	Y # open: 0 # total: 5	Y univent (off)	Y closet	Hallway DO, DEM, plants.
Library	0	70	33	588	ND	ND	28	Y # open: 0 # total: 4	N	N	Hallway DO, #WD-CT : 1.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WD = water damage
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Goodyear Elementary School | **Indoor Air Results**

41 Orange St., Woburn, MA | **February 16, 2005**

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									Supply	Exhaust	
14	16	73	32	844	ND	ND	27	Y # open: 0 # total: 4	Y univent (weak)	Y	Hallway DO, DEM.
10	17	72	33	1049	ND	ND	25	Y # open: 0 # total: 4	Y univent (weak)	Y closet	Hallway DO, cleaners, Comments: broken window.
Gym	0	76	31	443	ND	ND	21	Y # open: 0 # total: 5	Y univent	Y wall	Hallway DO, Comments: 2 of 3 univents "on".
16	17	75	35	1525	ND	ND	26	N # open: 0 # total: 0	Y univent furniture	Y closet	Hallway DO, DEM, cleaners, temperature complaints (cold).
Fenton/Portable	14	75	34	1068	ND	ND	26	Y # open: 0 # total: 3	N	Y ceiling	Hallway DO, window-mounted AC, DEM, plants.

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Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Lane/Portable	16	73	33	873	ND	ND	30	Y # open: 0 # total: 2	Y ceiling		#WD-CT : 1, DEM.
19/Portable	18	73	38	927	ND	ND	25	Y # open: 0 # total: 6	N	Y ceiling	Hallway DO, window-mounted AC, DEM, Comments: Water damaged building materials replaced.
20/Portable	18	75	34	657	ND	ND	27	Y # open: 0 # total: 3	N	Y ceiling	
18	2	75	33	838	ND	ND	34	N # open: 0 # total: 0	N	Y wall	Comments: Snow blower-slight fuel odors, recommend passive vent in door for air exchange.

ppm = parts per million
µg/m3 = micrograms per cubic meter

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aqua. = aquarium

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CD = chalk dust
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CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WD = water damage
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Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Goodyear Elementary School | **Indoor Air Results**
41 Orange St., Woburn, MA | **February 16, 2005**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Main Office	2	73	32	682	ND	ND	33	N # open: 0 # total: 0			Temperature complaints (cold), Comments: no heat-disconnected.
4	15	74	34	591	ND	ND	32	Y # open: 1 # total: 4	Y univent (off)	Y closet items	DEM, plants.
Nurse	1	74	33	622	ND	ND	37	Y # open: 0 # total: 1	N	N	Hallway DO, Comments: recommend passive vent in door for air exchange.
3	21	74	35	774	ND	ND	36	Y # open: 1 # total: 5	Y univent (off)	Y closet	Hallway DO, plants.
2	19	74	34	866	ND	ND	41	Y # open: 0 # total: 5	Y univent (off)	Y closet	DEM.

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									Supply	Exhaust	
6	21	73	33	790	ND	ND	33	Y # open: 0 # total: 0	Y univent	Y closet	Hallway DO, AP.
7	24	74	33	669	ND	ND	41	Y # open: 0 # total: 5	Y univent		DEM, plants.
11	18	70	34	725	ND	ND	28	Y # open: 0 # total: 4	Y univent (weak)	Y closet	DEM, cleaners, temperature complaints (cold).
Computer Room	0	70	30	603	ND	ND	24	Y # open: 0 # total: 4	Y univent	Y closet	Hallway DO, window-mounted AC, Comments: mimeograph machine.
Teacher's Lounge	2	73	36	456	ND	ND	33	Y # open: 0 # total: 1	N	N	Hallway DO,

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February 16, 2005

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									Supply	Exhaust	
Cafeteria	50	69	44	885	ND	ND	33	Y # open: 1 # total: 8	Y ceiling (off)	Y ceiling (off)	Hallway DO, Comments: 2 ceiling-mounted air handling units reportedly inoperable.

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	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
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